

WIND | IS WIND POWER **KNOWLEDGE**



A dynamic line rating system based on CFD for planning and operating transmission lines

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windsim

Outline

- Who we are
- Why we focus on CFD based dynamic line rating
- How dynamic line rating based on CFD works
- Validation of real time dynamic line rating
- Using CFD and ANN for dynamic line rating forecasting
- Optimization of planning and routing of new power lines
- Conclusions

Who we are: WindSim AS

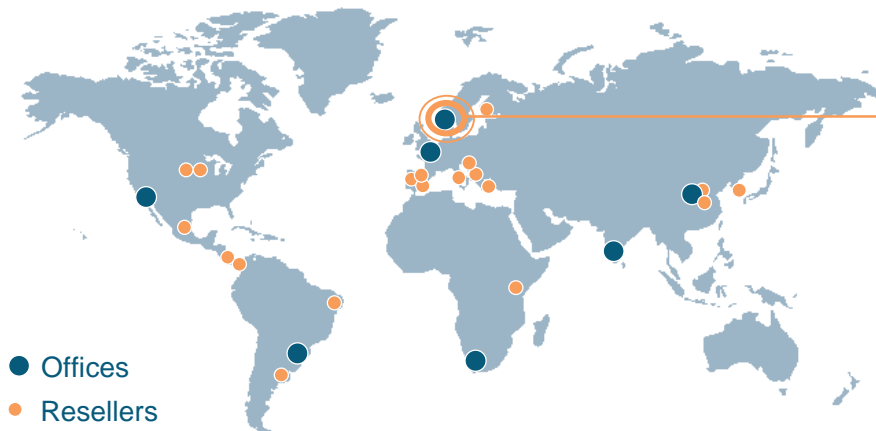
- Company established in 1993, privately held
- WindSim - CFD based Wind Farm Design Software launched in 2003
- Business areas
 - Software solutions, consulting services and training
 - Wind energy assessment and wind simulations
 - Wind farm lifecycle
 - Onshore and offshore
 - Other wind assessment
 - Power line and grid optimization
 - PV industry



WindSim HQ in Tønsberg, Norway

- WindSim AS has customers in over 50 countries

- Customer segments:
 - Turbine manufactures
 - IPPs
 - Wind farm developers, owners and operators
 - Engineering and consulting companies
 - Research institutes
 - Universities



WindSim has offices in Norway, China, Brazil, France, India, South Africa and USA

Who we are: Idaho National Laboratory (INL)

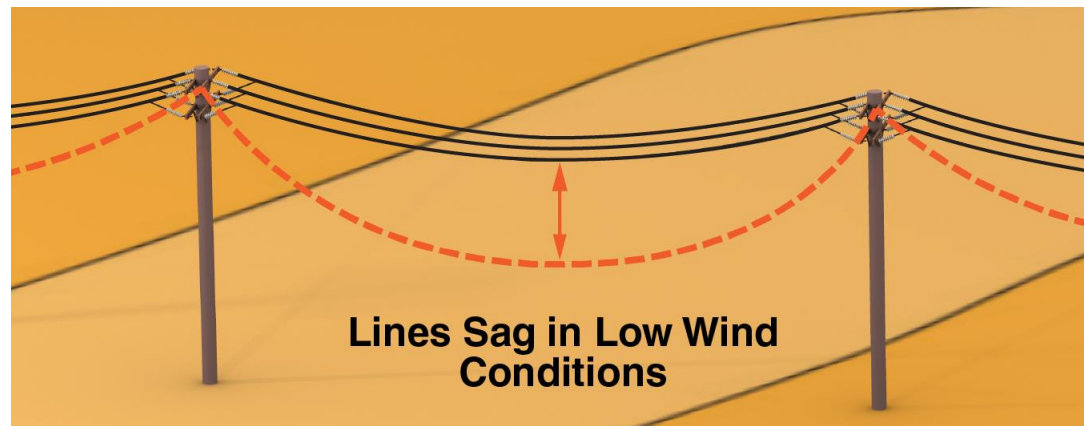


Motto	<i>The energy of innovation</i>
Established	1949
Research type	Nuclear energy, national security, energy, and environment
Budget	~ \$1 billion (2010)
Director	Mark Peters
Staff	~ 4,100 (2010)
Location	Idaho Falls, Idaho, U.S. & a large area to the west
Campus	890 sq mi (2,310 km ²)
Operating agency	Battelle Energy Alliance
Website	inl.gov 

- Idaho National Laboratory (INL) has worked on Dynamic Line Rating (DLR) for a number of years and bought a WindSim license in 2009 for integration in their solution
- WindSim and INL have since 2009 worked together to extend the WindSim software for calculating wind along power lines over long distances and for power line routing optimization

Why we focus on CFD based dynamic line rating

- The main restriction on electric power transmission through a power line is the thermal limit of the conductor
- High temperatures cause deeper conductor sag and may result in clearance violations
- High temperatures cause annealing that weaken the conductor and may result in irreversible elongation



Why we focus on CFD based dynamic line rating

Static rating

Static rating considers a worst case scenario of conditions or historical averages for calculating a steady state declared transmission capacity of a line

- High temperature
- Low wind speed
- High solar radiation

Dynamic rating

Dynamic rating uses actual operating conditions to calculate the capacity of lines. Parameters includes

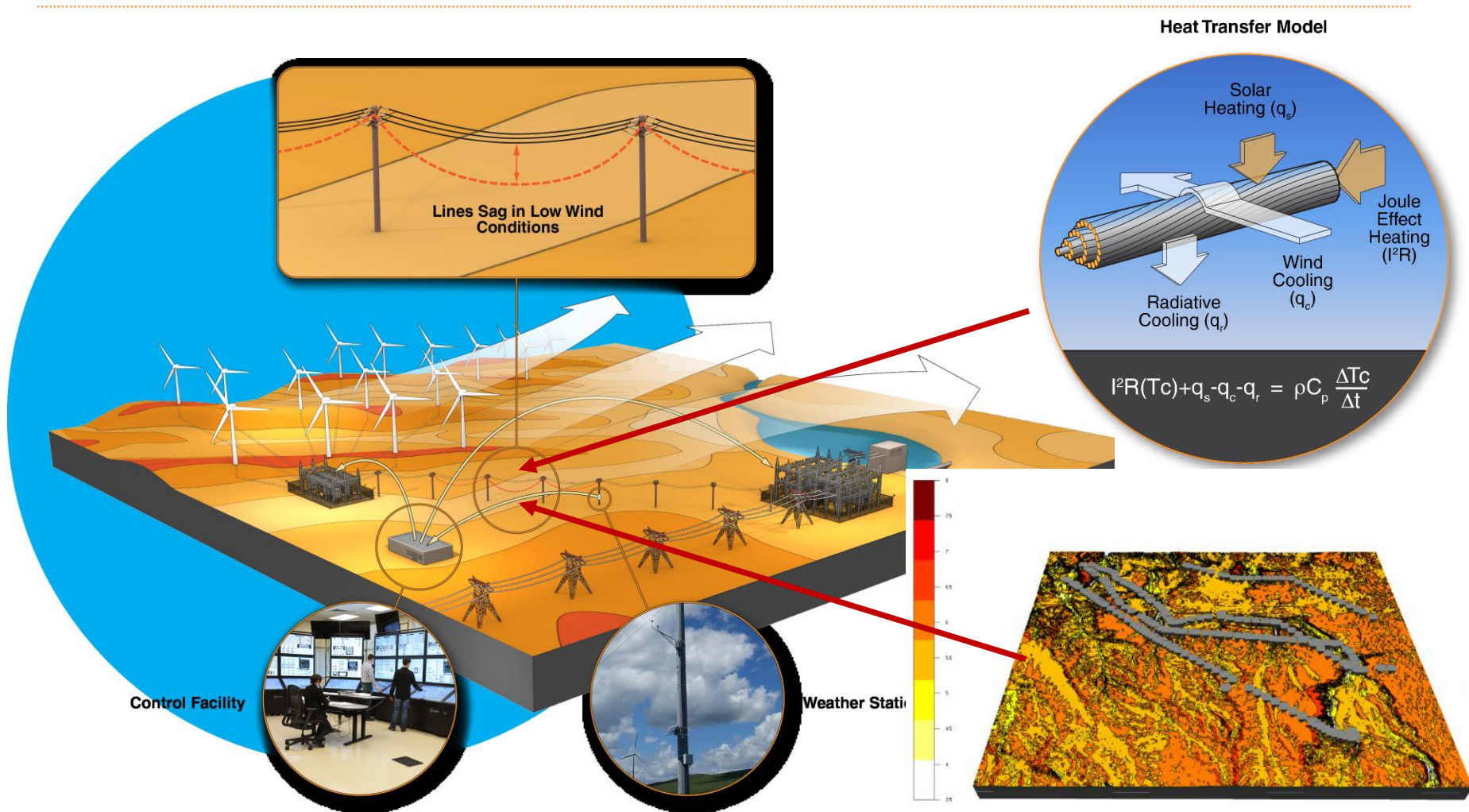
- Air temperatures
- Wind speed
- Wind direction
- Solar radiation

- Without accurately measuring the environmental conditions and their effects, lines can be critically underutilized
- The conservative static ratings may not suffice under true worst-case situations with extreme weather conditions thus in cases overloading the lines
- **Dynamic Line Rating technologies enable transmission owners to determine capacity and apply line ratings in real time. This enables system operators to take advantage of additional capacity when it is available**

Why we focus on CFD based dynamic line rating

- Reduce investments in new lines
- Renewable energy as wind/solar farms are built in remote areas with limited suitable power grid connections. In addition their energy production correlates with weather and dynamic rating capacity
- **DLR can make or break a new wind farm profitability**
- An increase in wind speed blowing at a right angle to a high-voltage line can cool the line enough to safely increase the amount of current it can carry by 10 to 60 percent

How dynamic line rating based on CFD works

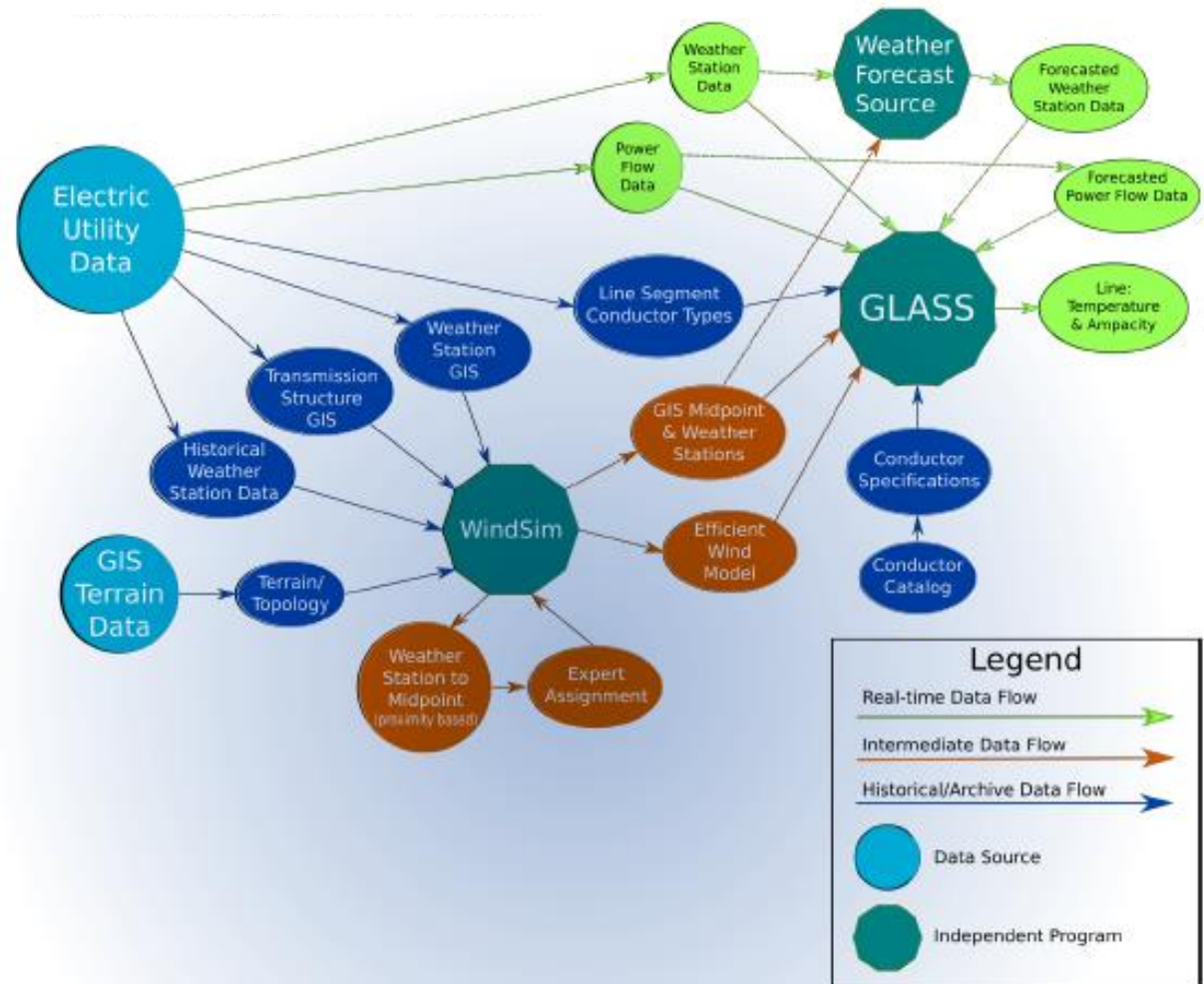


How dynamic line rating based on CFD works

The DLR solution is build up of three independent software programs:

- WindSim: Numerical model for the efficient calculation of wind speed and wind direction along the power line
- Weather Forecast Source: To make detailed real-time forecasts based on historical forecasts and measurements
- GLASS: INL’s software for integration of the wind model, weather forecast, power flow and conductor information to calculate real-time line temperature and capacity

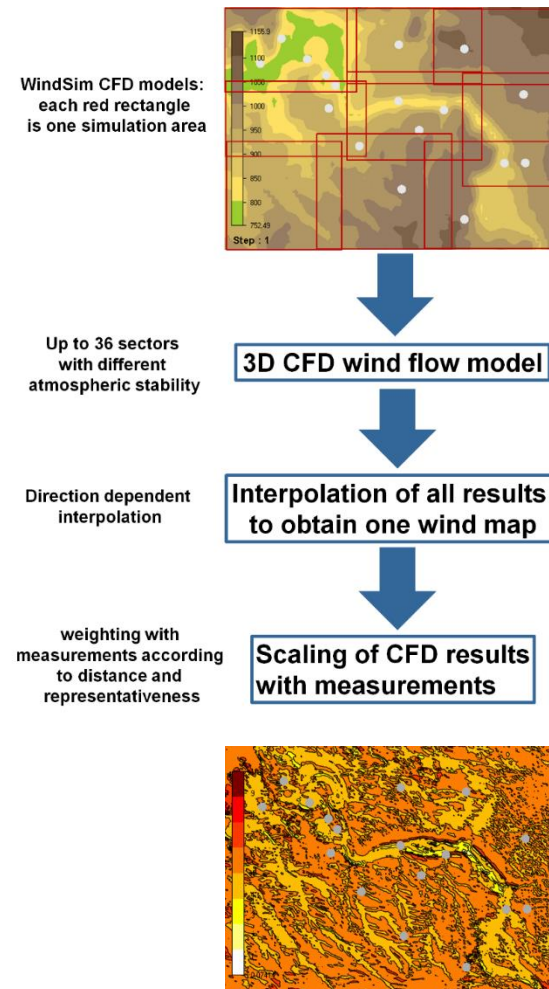
Real-time Data Flow



How dynamic line rating based on CFD works

- Transmission lines span over several hundreds of kilometers which is normally a too large area for CFD simulations
- Solution: Combine several CFD simulations into one large model and do the postprocessing and transfer calculations in that large model

CFD Windatlas method for large areas



How dynamic line rating based on CFD works – Pros and Cons

PROS

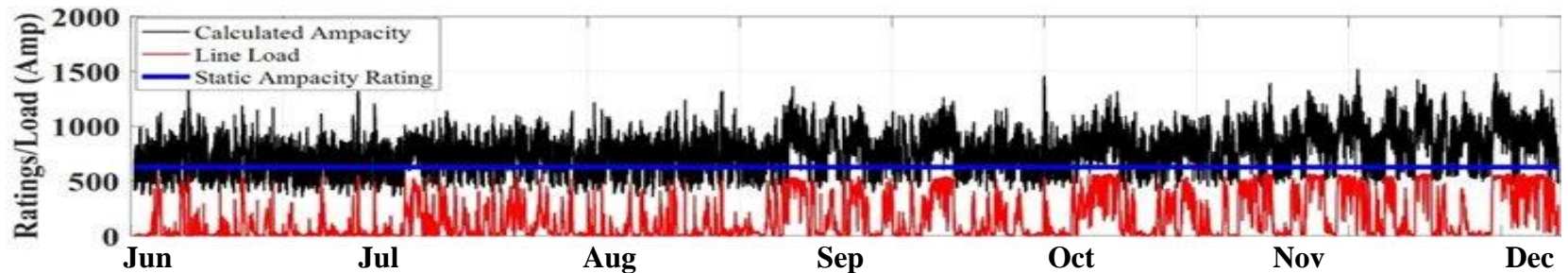
- CFD has a very high horizontal resolution (10-30 m) and can capture the local flow around the transmission line
- It is cheap and computationally affordable
- Look-up tables are created beforehand such that the DLR can be done within seconds

CONS

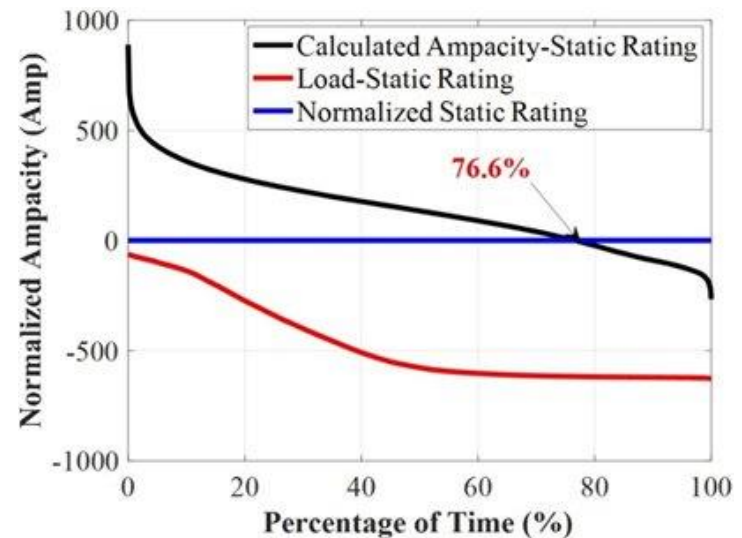
- CFD can only account for a limited amount of atmospheric processes
- The quality of the model depends on the accuracy of the terrain and roughness map

Validation of real time dynamic line rating based on CFD

- INL has done a thorough validation of the method by comparison with field-testing done in conjunction with AltaLink. Sample results on one feeder is presented in this study

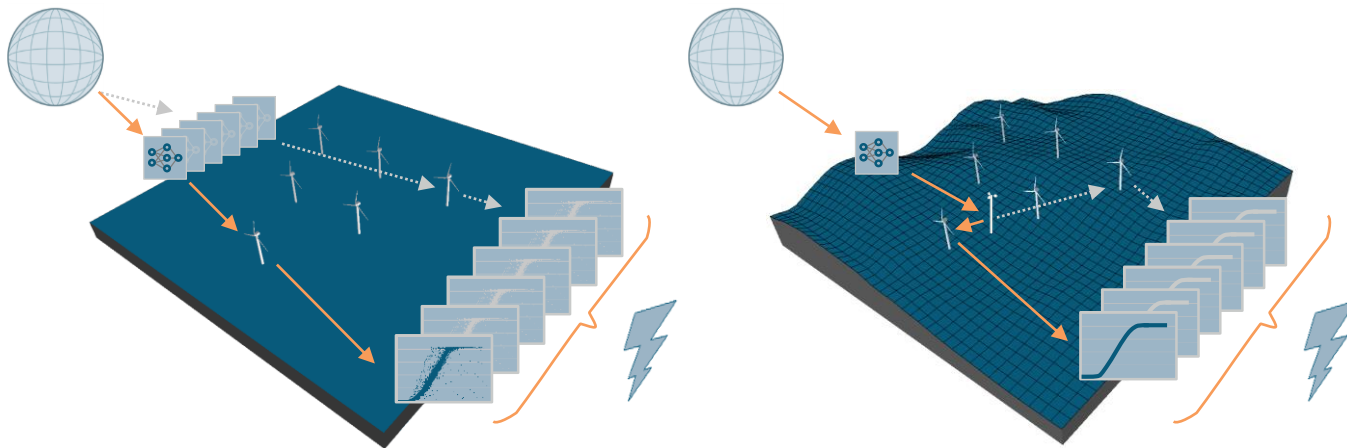


- The results demonstrated that real-time ratings were above the seasonal static ratings for at least 76.6% of the time, with a mean increase of 22% over the static rating



Using CFD and ANN for dynamic line rating forecasting

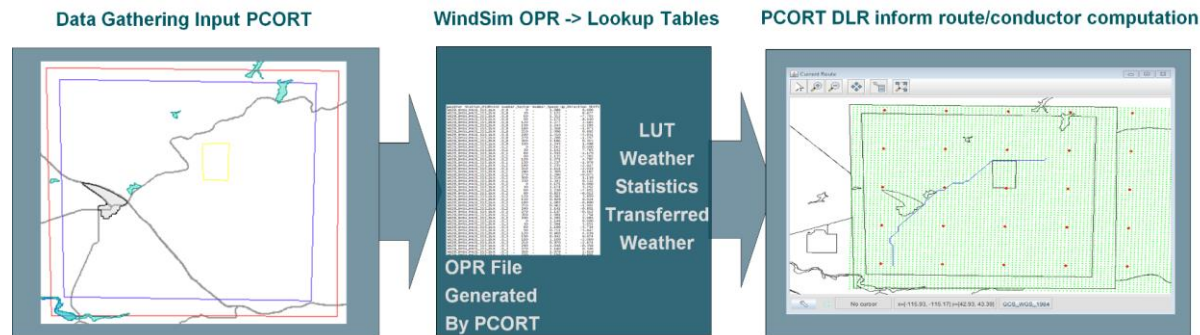
- From real time monitoring, this approach can also be extended to forecasting the capacity of the line for the next interval of minutes, hours, and even days
- A combination of Artificial Neural Network based mesoscale model wind speed correction and CFD downscaling is used



WindSim Portal: Established power forecasting strategies using various combinations of Artificial Neural Networks and Computational Fluid Dynamics can be used within DLR

Optimization of planning and routing of new power lines

- Optimization by calculating the wind speed and wind direction at every grid point in the routing area with the WindSim OPR tool:



Data flow overview: from configuration in Planning, Conductor Optimization, and Routing Tool to WindSim Objects Planning and Routing Module back to PCORT

- Route optimization of the line informed by weather, CFD, and DLR
- Conductor choice on lines to wind farms can be optimized through synergistic accounting of line cooling concurrent with wind energy generation
- Enables smallest least expensive conductors with smaller structures
- Enables optimal decisions on need to upgrade conductors for expanding existing wind farms

Conclusions

- WindSim and Idaho National Laboratory have developed a dynamic line rating solution based on CFD
- The solution can be used for nowcasting, forecasting and planning & optimization of new lines
- For nowcasting an increase in transmission line capacities of up to 40% has been proven
- We are looking for industrial partners

Thank you

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